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Raising achievement through formative assessment in science and mathematics education (FaSMEd)

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This paper will report on the ongoing work and progress of the FaSMEd project, which is a design research project, now in the second year of a three year programme. FaSMEd aims to develop the use of technology in formative assessment classroom practices in ways that allow teachers to raise achievement in mathematics and science. This international project adapts and develops existing research-informed pedagogical interventions (developed by the partners), suited to implementation at scale, for raising achievement and transforming teaching. The project aims to: foster high quality interactions in classrooms that are instrumental in raising achievement and expand our knowledge of technologically enhanced teaching and assessment methods addressing achievement in mathematics and science. The project will be producing a toolkit for teachers to support the development of practice and a professional development resource to support it.

Key words: Formative assessment; mathematics; science; technology; design study; achievement

Concept

This international project adapts and develops existing research-informed pedagogical interventions (developed by the partners), suited to implementation at scale, for raising achievement and transforming teaching. The intervention is cross-subject, focused on the development of technologically enhanced practices of formative interpretations of assessment[1] within day-to-day teaching approaches. The project focuses on upper primary and lower secondary age students (11-14), since this is an age group where teachers are actively shaping new norms of classroom participation and where it is relatively free from the 'backwash' effect of preparation for examination.

The partners in this project are:

- University of Newcastle upon Tyne, UK (Coordinator)
- The University of Nottingham, UK
- Ecole Normale Supérieure De Lyon, France
- National University Of Ireland Maynooth
- University Of Duisburg-Essen, Germany
- University Of Turin, Italy
- Freudenthal Institute, University Of Utrecht, The Netherlands
- African Institute For Mathematical Sciences Schools Enrichment Centre, South Africa (Stellenbosch)
- University College Of Trondheim, Norway

The project draws on evidence from large scale systematic reviews of educational interventions which reveal that the effect size on achievement of interventions that focus on the development of teaching using formative interpretations of assessment in classrooms is significantly greater than most other intervention approaches (Hattie, 2009). A key element of this diagnostic approach to teaching using assessment and intervention relates to the quality of the information generated by the various feedback loops that exist in the classroom setting and the involvement of the students within this process. Hence, the introduction of innovative technological tools to create a digital environment which enhances connectivity and feedback to assist teachers in making more timely formative interpretations has the potential to amplify the quality of the evidence about student achievement in real-time for access by both students and teachers.

Objectives

The objectives for the project are to:

- produce a toolkit for teachers to support the development of practice. (NB. The expression 'toolkit' refers to a set of curriculum materials and methods for pedagogical intervention)
- produce a professional development resource that exemplifies use of the toolkit.
- offer approaches for the use of new technologies to support formative assessment.
- develop sustainable assessment and feedback practices that improve attainment in mathematics and science.
- disseminate the outcomes of the project in the form of online resources, academic and professional publications, conference presentations as well as policy briefs to government agencies at a regional, national, European and international level.

Research questions

In order to establish the educational context, the project seeks to: report the differences in the way that systemic structures influence underachievement within the participating countries. It has reported on the varying assessment tools that are used to identify underachievement, with attention paid to the different interpretations of achievement in each country. The research has surveyed the current policies and practices in formative assessment and teaching in the partner countries and beyond. The research has also surveyed the technology currently available in classrooms to support formative assessment of students' understanding in mathematics and science. (See http://research.ncl.ac.uk/fasmed/deliverables/ D2.1, D2.2, D2.3 for details).

Case studies produced from each of the project partners will report on:

- How do teachers process formative assessment data from students using a range of technologies?
- How do teachers inform their future teaching using such data?
- How is formative assessment data used by students to inform their learning trajectories?
- When technology is positioned as a learning tool rather than a data logger for the teacher, what issues does this pose for the teacher in terms of their being able become more informed about student understanding?

Scientific methodology and associated work plan

The scientific strategy for this project is design study. Shavelson, Phillips, Towne & Feuer (2003, p. 26) suggest that the key principles of design studies are that they are:

a) iterative; b) process focused; c) interventionist; d) collaborative; e) multileveled; f) utility oriented and g) theory driven. Hence the design of the project is an iterative, collaborative, process-focused approach to the development of the toolkit for teachers, evaluation of technologies and professional development and builds on research evidence for approaches which have the greatest impact. However, pedagogical improvement at scale must take account of the existing state of the system and the resources and practices already in place. These constraints imply the adoption of a 'redesign' stance building on existing practices and research.

Evaluation is a constant theme in design study and this is aimed to be a 'learning and development project' where design does not cease after the first phase but is carried through by formative evaluation of the process of the project through reflection and evaluation by the participants.

The project is organised in three phases. The first year began with the development of the theoretical and methodological framework for the project. The framework was then used to establish a baseline of current practice and achievement in mathematics and science education in the EU and internationally; research innovative practices and technologies for supporting formative assessment, develop a prototype toolkit and professional development protocol and select appropriate schools and students for the study. Dissemination and conferencing among the partners was an integral element of the project from the beginning with the development of a website a priority. A strategic advisory committee consisting of representatives of technology companies and academic advisors has been appointed and has been regularly providing input into the design process and quality control. The year finished with an event to launch the main intervention.

During the second year the main intervention in schools is iteratively initiating the approach(es) and professional development process, with frequent opportunities to evaluate and share progress among participants. Students' initial achievement and final achievement is measured using locally available instruments. A sub-contractor is filming the development process among a range of schools, teachers and students.

During the third year the final report will be compiled and the final version of the teachers' toolkit and the professional development package produced. Cross comparison case studies will be published and a conference will be held to launch the final report.

Application of state of the art research

The project builds on the results of existing research studies concerning the raising of attainment levels within mathematics (Ruthven, 2011; Watson & De Geest, 2005) and science (Shayer & Adey, 2002), low achievement (Ahmed, 1987), formative interpretation of assessment (Black, Harrison, Lee, Marshall, & Wiliam, 2003), the integration of technology (Hegedus & Moreno-Armella, 2009) and on best evidence syntheses of teacher learning (Timperley, Wilson, Barrar, & Fung, 2007). The project specifically includes South Africa in order to provide a contrast to the situation in more developed countries(Carnoy, Chishom, & Chilisa, 2012) and to provide a robust test for the implementation of the strategies developed by the project.

The project also draws on the experience of colleagues at Nottingham University who, in partnership with the University of California, Berkeley and supported by the Gates Foundation, have developed a range of assessment materials for US teachers and students to support US schools in implementing the Common Core State Standards for Mathematics (CCSSM). In science, several of the partners can draw on their work in inquiry based learning in science and mathematics as partners in the EU funded projects such as Compass, a Comenius project (Common problem solving strategies as links between mathematics and science) and Primas, an FP7 project (to promote inquiry-based learning in mathematics and science at both primary and secondary levels across Europe).

The impact of technology and raising achievement

The creation of a digital environment in the classroom has particular benefits for raising achievement. For example, the facility to respond ‘anonymously’ to questions from teachers or peers reduces the anxiety levels which research shows has a significant impact on participation. Also, the facility for teachers to carefully track individual responses supports a more focused diagnostic intervention with students, a key element in supporting the progress of those students who can often be lost in the wider mass of the classroom (Shirley, Irving, Vehbi, Pape, & Owens, 2011).

The use of digital environments in classroom in recent years has changed from a more “private” to a “public” use that integrates private use (Hegedus & Moreno-Armella, 2009; Robutti, 2010) as predicted in Sinclair & Jackiw (2005). This shift, which echoes the historical shift from the use of individual handheld slate to blackboards, is recognised by recent literature about the relationships between the use of “private” activity (individual or in small groups) and “public” activity (to which all the students participate). The public screen not only displays the student work in real time, providing immediate feedback, it enables individual students to compare and connect their own work with that of others. In addition, the rapid development of small mobile devices gives an opportunity for students to access technology as and when they need it in the classroom.

Progress beyond state of the art

This is a complex educational challenge, since there is no clear characteristic of low achievement in mathematics and science. While students share the common feature of underachievement, such groups typically contain a disproportionate number of those from disadvantaged social, cultural and ethnic groups, and in some countries without a good command of the first language of the classroom (Boaler, Wiliam, & Brown, 2000; Ireson & Hallam, 2001). Established approaches for working with such students are frequently characterised by a ‘deficit’ model of their potential which entails repeating material from earlier years, broken down into less and less challenging tasks, focused on areas of knowledge which they have previously failed and which involve step-by-step, simplified, procedural activities in trivial contexts. In contrast, the TIMSS seven-nation comparative study shows that high achieving countries (Hiebert et al., 2003) adopt approaches which preserve the complexity of concepts and methods, rather than simplifying them.

Progress and achievements

The project is now in its second year and we have agreed on the research protocols to be used (case study research); produced a glossary of the main concepts drawn on and completed surveys of the landscape for under-achievement across Europe and South Africa in science and mathematics and surveyed the use of tools and technologies to support learning in science and mathematics.

Prototype toolkits and professional development approaches have been produced – for example, see https://toolkitfasmed.wordpress.com/ where a website exemplifies some of the activities and approaches adopted.

Schools

Partners are now working with clusters of schools to trial the activities and provide the feedback necessary to develop the materials, approaches and guidance which comprise the toolkit. The interventions are expected to be carried out between January and July 2015, although some may continue after the summer break. Case studies will be completed for each school with a selected teacher as a focus in order to provide exemplars for the toolkit and data for further research studies to be carried out in the third year of the project.

Approaches adopted

We are aware that we necessarily build on existing practices and research. Hence in the UK, the approach to mathematics activities adopted those developed at Nottingham University and exemplified on the MAPS website (http://map.mathshell.org/) and each school has been invited to adopt a technology which they felt able to implement with a relative minimum of effort. In the UK we have a range of technologies being trialled including Chromebooks with Googledocs software, Ipads with Socrative and Classflow software and several other combinations of software and hardware. As a contrast, in South Africa, where access to any sort of technology is limited, a number of low tech 'tools' are being trialled to provide the feedback necessary for formative assessment in the mathematics classroom, since both the concept and practice of formative assessment are relatively new.

Other partners, such as Utrecht and Duisburg-Essen, are developing digital environments where the activities provide tools for classes or individuals to diagnose understanding and obtain feedback.

Crossing boundaries

Akkerman & Bakker (2011) provide an interesting study of the main issues arising when boundaries (defined as: "a sociocultural difference leading to discontinuity in action or interaction." p.132) are encountered or crossed. They point out that although these situations can be uncomfortable, they also provide opportunities for learning – particularly through dialogue and identify four mechanisms through which this can be achieved: identity, co-ordination, reflection and transformation. This project is certainly engaged in crossing boundaries and our experiences so far provide ample opportunities for dialogic learning in questions of identity, achieving co-ordination, reflecting on issues and transforming practice. We are producing a film which, we hope, will capture some of these moments and tell more of the story of FaSMEd.

Notes

1. Defined by Black, , & Wiliam, (2009, p.9) as 'Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited'.

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